NASA-TM-110688

- SOFIA TELESCOPE ISSUES -

60192

P-6

SOFIA TELESCOPE ASSEMBLY DEFINITION INTERIM REVIEW: BY J.A.DAVIDSON 3/15/89

The DLR held the SOFIA Telescope Assembly Definition Interim Review at Carl Zeiss, Oberkochen, W.Germany, on February 23-24 1989. Below is a list of questions composed before the meeting by the Project Scientist, many of which were answered. However, many details had to be missed in order to cover only the most critical problems, since the duration of the meeting was very short. The most servere problem encountered was related to the Vibration Isolation System (VIS). This is discussed in detail below.

Carl Zeiss is responsible for the telescope optics, tracking and control systems; MAN is responsible for the metering structure of the telescope and the airbearing; and Dornier is responsible for the VIS and pointing control system.

QUESTIONS AND ANSWERS:

MAN proposed a CFRP "Nasmyth" TUBE connecting bearing and centerpiece. This was not stiff enough in their phase A study. How do they get adequate stiffness now? What are plans for routing cables through the tube? What will the inside dimensions available to the experimenters be?

MAN is confident of their structure. The CFRP they plan to use for the Nasmyth Tube and the Telescope Centerpiece sturcture is a new High Modulus Fiber (HM-Fiber). The tube is connected to the centerpiece and to the airbearing by INVAR rings called fixtures. These are bonded and bolted to the CFRP structures. A third INVAR ring is located halfway between the centerpiece and the airbearing to increase the stiffness of the tube. The clear inner diameter of the Nasmyth tube and the INVAR rings is 76 cm at all angles as required in SOF-1011. This diameter is not in jeopardy since MAN says it is necessary for the Nasmyth tube's stiffness, and the size of the airbearing is necessary to carry the load of the telescope. The inner wall of the tube is for insulation. Between the insulation and the outer tube structure there is enough room for all the cables. The walls of the Nasmyth tube structure are 5 cm thick. Such a thickness for CFRP is not easily achieved.

The estimated mass of the CFRP telescope structure, Nasmyth tube and airbearing (see below) is only 3710 kg, compared to an equivalent metal structure with the same stiffness, of 8740 kg. The Ames phase A report had a budget of approximately 10,000kg (mostly in the airbearing).

Can the TERTIARIES be closer together to increase the space available for experimenters? A small amount of vignetting of the visible beam should permit significant reduction of the separation of IR and visible beams. The tube around the IR tertiary shown in the telescope drawing is undesirable for IR work.

The question of vignetting the visible beam was not addressed since the Nasmyth tube has (from the MAN design) ample room. There was disagreement among the scientists at the meeting whether the tertiatry mirror should be oversized (i.e., be the defining obscuration of the primary

(NASA-TM-110688) SOFIA TELESCOPE ASSEMBLY DEFINITION INTERIM REVIEW (NASA. Ames Research Center) 6 p

N95-71644

Unclas

19/74 0060192

instead of the secondary), or as it is presently defined in the SOF-1011. Hence, the question of the tertiary tube was not raised. Dr. Paul Harvey agreed to estimate the tertiary size required to minimize IR noise generation.

Is aluminum being considered for the SECONDARY material? This would have advantages for the CHOPPER. Are problems anticipated in achieving the requested chopper performance? Is the secondary mirror difficult to figure?

Zeiss is just beginning their design work on the chopping secondary. The quality and construction of the secondary MIRROR (probably Zerodur) was not discussed.

The secondary mechanism chops in one axis, using two pairs of actuators, with a rotation drive for the chop direction, and a counter mass for reaction compensation. The dither function has no reaction compensation. The focus drive is independent from the dither drive, (which seems redundant). The total weight is expected to be between 60 and 80 kg. This design may have to be completely changed since there was a misinterpretation of the SOF-1011 requirement which gives the chopper amplitude verses frequency characteristics. The true requirement requires far more power and reaction compensation than Zeiss first thought. Larger actuators might distort the secondary mirror surface and they might not be able to fit in the present design. On top of this they were not aware that the chopper must be able to chop and dither simultaneously.

A presentation was qiven on the expected coma from an f/1.1 telescope with the secondary tilted by 4 arcmins (on the sky). When the tilt was about a pivot 30mm behind the vertex of the secondary (the nominal design) the coma diameter was 16". If the pivot was at the prime focus (approximately 300mm behind the vertex), then the largest coma diameter in the field of view would be 4". Unfortunately, the prime focus is out in the wind.

MAN proposes to make the bearing largely out of CFRP. What are the details and concerns? Cooling the bearing in flight seems like a good idea.

Once again MAN is confident, and is not concerned with the size of the bearing (54 inches in diameter). The bearing will be made from CFRP coated with a ceramic or metal. The air gap will be 10 microns with a (+/-) 5 micron variation. The airbearing will have an air consumption of 60 g/sec with a pressure of 10 bar. The air will flow through 24 porous bronze stator pads. These pads will be forced toward the bearing center with passive soft springs for nominal automatic air gap adjustment. No active controls will be incorporated. Concerns (mostly by Dr. Sarver an engineer from Ames) were that particules of the size of the pores in the bronze could block the air supply; the pads cannot take pressures much greater than 10 bars before they "blow apart"; and after the pads are repeatedly "clamped " down on the bearing (no air flow), bronze particles of the size of 10 microns could eventually develop in the gap. The latter concern may never be a problem since the gap should be blown clean with every operation. MAN was asked to look into the maintainablity of their airbearing concept, so that if one pad needed to be replaced the whole system did not have to be disassembled. The sphere and pads must all operate at the same temperature; on the ground at "room temperature"; in flight all components would be cooled.

MAN still needs to do more complete studies to work out the details of the design. They are planning to test the pads by constructing a demonstration consisting of a 30cm diameter metal ball and three pads supported on a ring that can be rotated and translated to different configurations with respect to gravity.

What are the ISOLATORS really like? They are taking up prime real estate, but their geometry needs much better definition. What are the concerns about the amplification of fore-aft g-loads? Are the various requirements clear for the isolators?

Nobody really knows what the isolators look like as yet. Dornier is still in the theoretical stages of developing the VIS system (i.e., using beams and mass models). The problem is that the first dumbbell mode of the MAN Nasmyth tube is at 15 Hz which overlaps with the frequency of the expected vibrations of a 747SP (and it is approximately the organ pipe mode of the cavity). Dornier suggested a notch filtering system at 15Hz in order to control the 15 Hz vibrations. However, such an isolation system cannot effectively dampen the low frequency vibrations. (The Power Spectral Density (PSD) of the 747SP vibrations was supplied by Ames from Boeing records, and there is reason to believe that it has values that are too large. Ames is arranging to fly instruments on a 747SP to check on the PSD in the near future.) In order to effectively remove the low frequency vibrations Dornier suggested to Zeiss that a Image Motion Compensation (IMC) tertiary could be a solution. Zeiss readily agreed. However, a moving tertiary could produce servere IR background noise. The magnitude of this noise is being examined by Dr. Paul Harvey. The scientists at the meeting basically did not endorse the IMC concept, and asked if it were not possible to increase the bandwidth of the torquer control loop to control the lower frequencies. There was no clear response other than Zeiss and Dornier will look into it. Dr. G. Sarver (of Ames) was concerned that if Dornier tried to control a fundamental mode of the telescope structure that this could feed energy into higher structural modes causing a lot of problems. He said that the conventional wisdom is to make sure that the bandwidth of the VIS does not overlap the structural frequencies. Therefore, either MAN should try to increase the first mode of their structure above 20Hz (out of the spectral range of the PSD), or instead of Dornier using the VIS to control the 15 Hz dumbbell mode, MAN should construct a Surrurier Truss design around the Nasmyth tube that could compensate for the undersirable deflections under a load, and so not requiring the control of this mode. MAN is considering both suggestions.

The large space allocated for the vibration isolators, is due in part to the control of the 15 Hz mode with the large values given in the current PSD (which hopefully will change). At present the VIS travel range expected by Dornier is +/- 30mm in any direction.

The PLENUM in the recent drawing is probably not strong enough. Its design is coupled to the design of the isolators.

This question was not addressed. But it was too soon after the Boeing meeting for MAN to have followed up on the discussion at Wichita.

Why has the design value for the TORQUERS increased by a factor of 3 from their value in phase A?

When questioned on the size of their torquers, Dornier replied that they were oversized, and that they will probably be reduced by a factor of three. No good explanation was given.

What are the design considerations for the primary SUPPORT required for POLISHING?

Herr Meir said it was not known as yet if the same support system could be used during polishing and telescope operation. The Mirror Fabrication Hardware Study is about 2 months behind schedule, and it is not known how long it will take to polish and figure. The mirrors to be fabricated:

i) 500 mm diameter, 40mm thick (AR= 12.5)........Zeiss already has the Zerodur cut for this mirror

ii) 500 mm diameter, 8mm thick (AR=62.5)

iii) Actual SOFIA mirror, 2584 mm diameter, 60 mm thick (AR=43)

How does the telescope primary MIRROR SUPPORT handle lateral loads? What is the procedure for adjusting the supports to obtain the requisite image quality? How can the details of this support system depend so strongly on primary f-number as alluded to in Wichita?

Unfortunately, Herr Meir's talk on the mirror support structure, was dropped from the schedule because of a lack of time after the extended (but needed) discussion on the VIS. After the meeting Meir explained that for the f/1.1 mirror there would be 64 support points. Each would have three passive hydraulic pistons attached. These pistons are connected to all the other support points in such away as to provide an equal force at all points, at all elevations. (No drawings available) At present the two radial axes at each point (the other axis being the axial axis) have only one piston per axis. This means Zeiss is relying on the stiffness of the mirror for the low elevations in order to prevent torques from distorting the surface. If however, the mirror proves not to be stiff enough, then there will have to be two pistons per radial axis to counter this gravitational torque. The support system will still be passive at all elevations.

The main concern by Herr Meir, if the f-ratio of the primary is increased, is the delay and expense caused in phase B (not to mention the considerable extra work for himself). He does not know how an increase to an f-ratio of 1.2 will change the support structure until he carries out the study. However, a week after the meeting in Oberkochen (after Zeiss had had a chance to look at the new enlarged Boeing cavity) the DLR announced that an f/1.2 primary mirror will be studied. Hence, (a) the cavity is large enough for a longer telescope, and (b) the reduced costs of the primary mirror construction in phases C/D must have far out-weighed the additional expense in phase B to change the design.

Why is the TELESCOPE COST, according to the trade study, so insensitive to WEIGHT? The cost is typically estimated as a product of weight and complexity. One would think the cost would drop rapidly with increasing weight, due to decreasing complexity factor (i.e. technical difficulty) until the weight was quite large; then the complexity factor will decrease less rapidly than the weight is increasing.

This question was passed on the Dr. Ewald of the DLR, since the DLR is the agency concerned with the cost of the telescope. Dr. Ewald said that they had already instructed Zeiss to give them a detailed reason or revised curve on cost versus weight. This report is due at the time of Zeiss' final cost estimates for phase B.

Are CZ, Dornier comfortable with the VIDEO POINTING SYSTEM (VPS) requirements and solutions suggested by ARC? What will be the minimum update rate from the VPS to compensate for telescope

drift? What are the gyro drift rates anticipated? (Example: 0.1 arc seconds/second gyro drift would permit VPS input as low as once per second, allowing use of a CCD for the tracker camera.)

Carl Zeiss is comfortable with the VPS requirements and solutions suggested by ARC. Data from the Teledyne SDG-5 and SAGEM GSL-80 dry tuned gyros indicate that the drift of the telescope can be compensated for, except for the random drift of the gyros, to the required value of 0.02 arcsec per second. At this drift rate, the frequency of the tracking update need be only 0.04 Hz. Zeiss is confident that they can achieve the required sensitivity for the tracking cameras, with multipliers. They will, however, consider the use of a CCDs.

Most focal plane ALIGNMENT operations could be accomplished without entering the telescope cavity. However, boresighting an IR instrument to the focal plane camera requires detecting a compact infrared source which has a compact visible counterpart. For the present, other than expensive in-flight calibration, we see no alternative to using a source which mounts on the spider in front of the secondary and focusses in the focal plane. The effect on primary cleanliness would be minimized if the primary cover can remain closed while the tertiaries are exposed, as on the KAO.

Not addressed

Are there considerations for the telescope design which would affect the possibility of installing it behind the wing?

Not addressed